FORMATION OF SPINELS IN THE MESOSPHERE AFTER THE K/T IMPACT. A. Preisinger[1], S.Aslanian[1], F.Brandstätter[2] and F.Grass[3], [1]Technische Universität Wien. Institut f. Mineralogie, Kristallographie und Strukturchemie (Getreidemarkt 9, A-1060 Vienna, Austria, lpetras@fbch.tuwien.ac.at), [2]Naturhistorisches Museum, (A-1014 Vienna, Austria), [3] Atominstitut der Österreichischen Universitäten, (A-1020 Vienna, Austria).

Continuous Cretaceous/Tertiary (K/T) boundary sections were studied in the eastern Balkan Mountains at the Black Sea coast near BJALA, Bulgaria [1,2,3], in the Scaglia Rossa of the Apennines, 25 km north of Gubbio at CERBARA, Italy [4], and in the Betic Zone in the Barranco del Gredero near CARAVACA, Spain [5].

Spinels were extracted with a strong magnet from water suspensions of clays sampled stepwise at intervals of a few millimeters from the K/T boundaries and were investigated by X-ray powder diffraction, scanning electron microscopy (including EDS analysis) and instrumental neutron activation analysis (INAA).

Spinels from the east-west range of the Mediterranean area of ~3000km (Bjala - Caravaca) have structural and chemical compositions which are characteristic of the KT-spinels of the boundary clay sites. The majority of these KT-spinels (space group: Fd3m, formula unit: $A^{[4]}B_2^{[6]}O_4$ with partial inversion) are single crystals of Ni-rich MAGNESIOFERRITE spinels [6,7,8] of octahedral shape of 1-20 µm in sizes.

Table 1. Compositions of KT-spinels

		CARAVACA		CERBARA		BJALA		
	[cm]	ΔT+0.5 grey	K/T red	ΔT+0.5 red	ΔT+0.25 green	ΔT+0.4 grey	ΔT+0.2 grey	K/T grey
[4]	Fe^{3+}	0.69	0.63	0.66	0.61	0.60	0.62	0.62
	Mn^{2+}	0.02	0.01	0.04	0.02	0.03	0.03	0.03
	Zn^{2+}					0.01	0.02	0.00
	Fe^{2+}	0.29	0.36	0.30	0.37	0.36	0.33	0.35
[6]	Mg^{2+}	0.55	0.47	0.48	0.41	0.41	0.46	0.43
	Ni^{2+}	0.14	0.15	0.17	0.20	0.20	0.16	0.19
	Al^{3+}	0.30	0.22	0.14	0.11	0.20	0.20	0.20
	Cr^{3+}	0.25	0.25	0.09	0.25	0.18	0.28	0.18
	Ti^{4+}	0.01	0.01	0.01	0.00	0.01	0.01	0.01
	Fe^{2+}	0.01	0.01	0.01	0.00	0.01	0.01	0.01
	Fe^{3+}	0.74	0.89	1.10	1.03	0.99	0.88	0.98
	O^{2-}	4	4	4	4	4	4	4
Fe^{3+}/Fe_{total}		0.83	0.80	0.85	0.82	0.81	0.82	0.82
a [Å]		8.343	8.351	8.367	8.364	8.356	8.356	8.355
ρ[g/cm^3]		4.66	4.76	4.80	4.86	4.81	4.76	4.80

The average cation compositions (cation/formula units), the lattice parameters (*a*[Å]), and the calculated densities (ρ[g/cm^3]) of spinels from the K/T boundary sites of CARAVACA, CERBARA, and BJALA, are listed in Table 1.

Single crystals of these KT-spinels show etching pits on their (111) faces and a few etching figures of four sided pyramids inside the pits on (100) faces. These crystals have no homogeneous composition, since in the SEM they show higher Cr-content inside (Table 2). INAA shows inclusions of Ir in these crystals. Some crystals are twins or quadruplets. Crystals of larger size (>20 µm) show cyclic crystal growth resulting changing chemical composition within these crystals (Fig. 1).

Table 2. Compositions inside and outside of single crystals

		CERBARA		BJALA	
		inside	outside	inside	outside
[4]	Fe^{3+}	0.54	0.83	0.66	0.55
	Mn^{2+}	0.00	0.01	0.02	0.03
	Zn^{2+}			0.00	0.05
	Fe^{2+}	0.46	0.16	0.32	0.37
[6]	Mg^{2+}	0.46	0.73	0.56	0.44
	Ni^{2+}	0.08	0.10	0.10	0.11
	Al^{3+}	0.10	0.24	0.32	0.18
	Cr^{3+}	0.37	0.28	0.25	0.14
	Fe^{3+}	0.99	0.65	0.77	1.13
	O^{2-}	4	4	4	4
Fe^{3+}/Fe_{total}		0.77	0.90	0.81	0.82

The KT-spinels are distributed asymmetrically over very narrow sections (of few millimeters) of the K/T boundary clay. Their concentration peak corresponds to the maximum of the Ir-content.

In the K/T boundary clay of the Mediterranean area the amounts of KT-spinels of 1-10 µm in diameter are approximately constant (~0.004 wt%). The weighted mean sizes of these crystals change from west to east from 5.2, over 4.9 to 3.5 µm, resp. In addition to these more or less homogeneously distributed spinels of the size range of 1-10 µm, there are also larger KT-spinels (Fig. 1) with a decreasing size-gradient from west to east, so the total amounts of spinels from Caravaca over Cerbara to Bjala correspond to 0.100, 0.060 and 0.016 wt%, respectively.

The impact of the bolide of about 12 km in diameter at Chicxulub, Mexico, produced an energy of more than 10^{23} Joule. This enormous energy was transferred within seconds to evaporated material called the HOT FIREBALL distributing its condensed products globally, to asymmetrically distributed solid and molten materials called the EJECTA CURTAIN and the WARM FIREBALL [9], as well as to a MEGATSUNAMI in the subtropical ocean, the Tethys, expanding in direction east-west. The evaporated material, the HOT FIREBALL, (~2000km^3) [10] expanded with speed of ~40 m/sec, the cloud thus forming a closed ring around the Earth within 10 days.

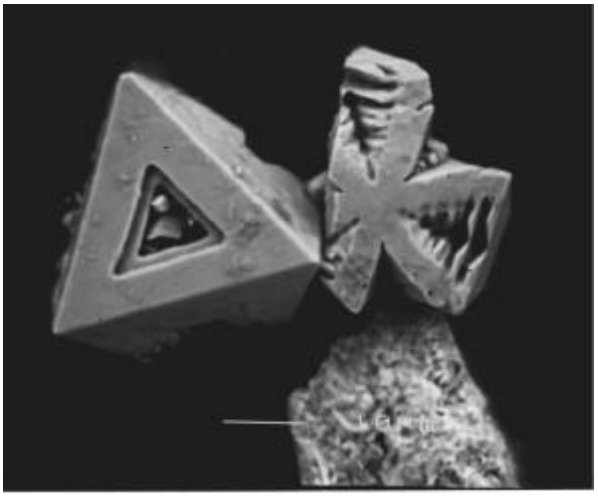

Fig. 1. BSE image of MAGNESIOFERRITE spinels from Caravaca: single crystal and quadruplet with layer crystal growth.

The evaporated material started to condense in the MESOSPHERE (at an altitude of ~100 km or higher) and sank to the STRATOSPHERE on its way to the EARTH surface.

The formation of the Ni-rich MAGNESIOFERRITE spinels might have started in the MESOSPHERE with heterogeneous nucleation on Ru, Ir-alloys resulting in crystal growth of spinel on it.

The falling time of KT-spinels of 2-20 µm diameter from the MESOSPHERE (100 km) lies in the range of 2000 to 20 days. On their way through the STRATOSPHERE they might have been etched by the H_2SO_4 aerosol.

The differences in size, shape, and chemical compositions of the investigated KT-spinels will be discussed in detail.

References: [1] Preisinger A. et al. (1993) Paleogeog. Paleoclimatol. Paleoecol., 104, 219-228. [2] Preisinger A. et al. (1996) Intern. Workshop Sept. 27 - Oct.2, 1996, Postojna, Slovenia, Abstract. 65. [3] Rögl F. et. al. (1995) Newletters, 5, 11-17. [4] Preisinger A. et al. (1996) Meteorics & Planetary Science, 31 Suppl., A111-A112. [5] Lindiger M. (1988) Mitt. Geol. Inst. TU Zürich. Neue Folge No. 272. Ph.D.thesis. [6] Kyte F. and Smit I, (1986) Geology, 14, 485-487. [7] Kyte F and Bohor F. (1995) Geochim. Cosmochim. Acta, 59, 23, 001-008. [8] Robin E. et. al. (1991) Earth Planet. Sci. Lett., 107, 715-721. [9] Alvarez W. et al. (1995) Science, 269, 930-935. [10] Pierazzo E. et al. Intern. Workshop Sept. 27 - Oct.2, 1996, Postojna, Slovenia, Abstract.